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SUGAR-BEET GROWING

UNDER IRRIGATION IN THE UTAH-IDAHO AREA

THE CONSISTENT PRODUCTION of increased tonnages of sugar beets of satisfactory quality per acre is the logical solution of certain pressing problems confronting both growers and sugar factories in the beet-growing areas. To this end recommendations of improved methods of beet growing are made and practices that have been found most satisfactory for the beet-growing regions of Utah and Idaho are outlined.

There is definite experimental evidence, the result of several years' work, to show that present beet-cultural practices are inferior to methods herein described, and that the adoption of these better practices will lead to an increased production of beets per acre without increasing the cost per ton.

Likewise, certain recommendations are made concerning the handling of the crop in years when curly top is prevalent as contrasted with years when that disease does not appear. It is believed that such information will prove to be of great benefit to the industry. Attention is also directed to the benefits from more complete utilization of sugar-beet by-products on the farm.

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SUGAR-BEET GROWING UNDER IRRIGATION IN THE UTAH-IDAHO AREA

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INTRODUCTION

THE GROWING of sugar beets for the manufacture of beet sugar has been an established industry in the irrigated region of the United States for almost 60 years. (Fig. 1.) During this period the area devoted to the culture of sugar beets has increased and new factories have been built. Some sections have shown a steady development of the beet-sugar industry, while in some others the attempts have not been successful. In some areas in which beets have long been grown the industry now utilizes practically all the land suitable for beet growing, and in other areas where suitable land might permit expansion of the industry crop competition is checking the increase in sugar-beet acreage. For many factories the situation to be faced is the securing of a large enough tonnage of beets of satisfactory quality for economical sugar production. In those areas where the expansion in acreage is definitely precluded, it is evident that the production of more tons of beets per acre is the logical solution of the pressing problem. As an improved situation in pest control develops, as irrigation projects are completed, thereby opening up new land, and as research in soil and cultural practices makes greater land utilization possible, an expansion of the beet industry may confidently be expected. There is, however, an urgent need for greater attention to the improvement of yields in the present areas of sugar-beet growing.

From the point of view of the grower, an increased yield of sugar beets is essential to more economical crop production. There are many opportunities for profitable improvement in the present methods of sugar-beet growing. The average yields for the areas in the irrigated territory under consideration are from 10 to 12 tons per acre, but there are growers in all of the irrigated areas who, by utilization of the best cultural methods, produce more than twice that quantity. It is reasonable to assume that many growers who now produce less than the maximum possible crop could by changed methods greatly increase their yields. There is experimental evidence to show that many of the practices of sugar-beet culture are inferior to other more desirable methods which produce increased yields without additional cost. The basic costs, such as land rental, seed, and many of the items of crop handling, are approximately the

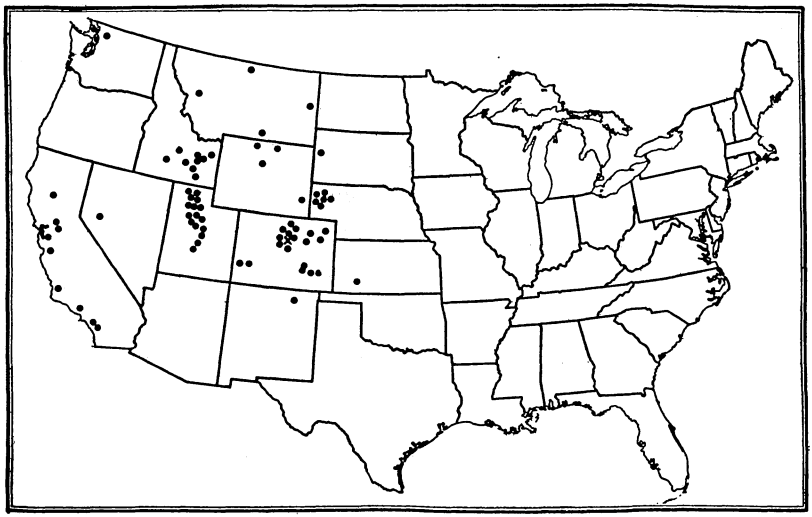

FIGURE 1.—Map showing (by dots) location of western beet-sugar mills. In the areas surrounding these mills more or less irrigation is necessary for the successful production of sugar beets. The × indicates a factory for recovery of sugar from molasses

same per acre for a low yield as for a high yield. The purpose of this bulletin is to present in brief form an outline of methods of beet growing which represent the most successful practices for the Utah-Idaho area.

CLIMATIC INFLUENCES

While all climatic factors have more or less influence upon the growing of sugar beets, temperature, rainfall, sunshine, wind, and humidity play the important rôles. Extreme variation in any of these factors may make an area unsuitable for sugar-beet culture, because these extremes of climate often cause serious crop injury. Storm periods, freezes, and periods of drought are common causes of reduction in the yield of sugar beets.

The sugar beet needs a growing season of at least five months. Areas that have an average temperature of 70° F. for three summer

months and only slightly lower average temperatures for the spring and fall periods are generally best adapted to sugar-beet culture. Regions with even temperatures are better adapted for sugar-beet growing than areas where there are excessive variations in temperature. High temperatures are considered harmful to sugar beets, but there is a lack of exact data upon this point. There is a general impression, however, that temperatures exceeding 100° are harmful, as the fields usually fail to make a good growth during these periods of extreme heat.

On the other hand, extremes of low temperature affect the beet crop. Beets are more resistant to frost injury than most of the crops grown in the irrigated areas. Young plants at their first appearance above the ground are sometimes damaged by frost, but larger plants are not usually killed unless the temperature falls below 27° F. Young plants suffer most injury from prolonged periods of cold weather during which there is a lack of sunshine. Cool weather in the fall is an important factor in bringing about storage of sugar. Light frosts during the ripening period hasten maturity and probably do little appreciable damage. Heavy freezes during the harvest season usually do not greatly injure the crop, if it has properly ripened, but they interfere with harvesting. During freezing weather precautions should be taken to prevent the freezing of beets that are piled in the field.

RAINFALL

Rainfall conditions have a profound effect upon the sugar-beet crop. The average annual rainfall in the irrigated region is usually less than 14 inches. The distribution of the rainfall throughout the year is exceedingly important. Many of the rains are light and have little effect on the soil-moisture content, hence they do not reduce the need for crop irrigation.

The rainfall in the winter and early spring months serves in many areas to store sufficient moisture in the ground to facilitate proper soil preparation. Fall plowing, as discussed later, influences the soil-moisture content appreciably. In some sections there is sufficient moisture in the soil or ample rainfall in early spring to germinate the seed when planted. However, in the greater part of this region there are occasional years in which there is insufficient moisture to bring about full germination of the seed. As a whole, growers in the irrigated areas put too much reliance on rainfall and fail to irrigate the beet crop sufficiently following planting and in the early stages of the crop. A forward step in sugar-beet growing in the irrigated area will be taken when the practice of prompt irrigation following planting is generally adopted. The rainfall during summer and early fall is usually light and may occasionally serve to reduce the number of irrigations necessary. The rains during the harvest season are beneficial in keeping the ground moist enough to facilitate pulling the beets. As will be seen in the discussion of irrigation practices, the amount and distribution of rainfall needs to be carefully considered in connection with applications of irrigation water.

WIND

Other climatic factors also need to be considered in connection with the sugar-beet crop. One of the most important of these is wind. In this western region drying winds increase evaporation from the plants and the soil. Since this region is one where a deficiency in natural rainfall exists, the greatest problem confronting the grower is one of supplying water to the crop and securing its retention in the soil. High winds, such as prevail after a rainy period, often bring about rapid drying of the soil and the formation of crusts, especially on heavy lands. Early restoration of the mulch by the use of the harrow, cultivator, or other especially adapted tools benefits the crop.

A type of wind effect, aside from drying, needs also to be mentioned. This is specifically known as wind injury or sand blast, which occurs on young plants exposed to the grinding effect of sand particles driven along the row by the wind. Such injury to beets is most serious on excessively sandy soils. Certain small areas are so subject to this wind injury in early spring that they are unsuitable for beet growing. Wind damage on sandy soils may be partially controlled by top-dressing the land with manure, plowing or harrowing when wet, planting the rows in the direction at right angles to that of the prevailing winds, and by the use of irrigation ditchers on the seeders. On other types of land a heavy rainstorm causes sand particles to lie on the surface of the soil in such a manner that they are easily picked up and shifted by windstorms. Under such conditions it is advisable to harrow or cultivate the field as quickly as possible after the rain.

HAIL

Agricultural crops grown in the western region frequently suffer from hail. There is no crop available for culture in this region which is able to recover from hail damage so successfully as sugar beets. Storms occurring in early spring cause the greatest damage because the small plants may be killed. Hail later in the season destroys only the leaves of the plants, the roots surviving. New leaves are then thrown out and the crop continues to grow. Under such conditions, although growth is checked during the replacement process and the crop is delayed, more or less recovery from the hail damage ensues. This is in marked contrast to the excessive loss suffered by other crops exposed to hail damage. This ability to recover from hail injury is an important feature of the crop, which makes the sugar beet valuable for the intermountain area of the United States in which hail injury frequently occurs.

FIELD SELECTION

LAY OF LAND

Not all soils nor all fields of an area in which beets are grown are suitable for beet culture. Careful consideration should therefore be given to the contours of the field, soil type, fertility, and the physical condition of the soil. Generally, the best sugar-beet lands in the irrigated region are those that have a gradual uniform slope

which allows the economical use of irrigation water. Fields that are uneven as to slope present many difficulties in row irrigation and should not be planted until properly leveled. Uneven fields are difficult to irrigate, as the low portions are flooded and the crop is damaged either by the washing and crusting of the land or by the scalding of the beets. Fields with a decided slope are inclined to wash badly when irrigated, and in order to secure sufficient storage of water in the soil excessive amounts of water are wasted. Proper utilization and conservation of irrigation water is essential. Better irrigation of some sloping fields sometimes may be secured by laying out the field so that the rows run at an angle with the slope. On flat fields, where the texture of the soil is such that the penetration of water is rapid, relief is found in shortening the run of water by spacing the laterals closer together.

SOIL TYPE

The type of the soil must be given consideration in the selection of fields for sugar-beet growing. The characteristics of certain soils are such that they may be rendered suitable for beets by proper preliminary handling, but in some cases the soils can not economically be made suitable for sugar-beet growing. Great variation in soils is found in the irrigated areas, the soil types ranging from heavy clay, medium clay, silt, sandy loam, pure sand, adobe, and volcanic ash to gravel soils. Most of these are slightly alkaline. The light and intermediate loams are best adapted to sugar-beet culture, as they are more easily handled, are least subject to serious crusting, and further, these soils usually produce better crop yields than other types. Very loose soils absorb water rapidly but do not retain it well, while very heavy ones absorb water slowly and retain it longer. The ability of a soil to absorb and hold water is very important in the irrigated areas. Heavy clays are somewhat better adapted to sugar-beet growing in the irrigated areas than is the case with beets grown under conditions of natural rainfall. The heavy clays are difficult to handle when either wet or dry, but as the irrigated region is generally one of light rainfall, the clay soils are seldom too wet for effective cultivation if proper control of moisture content through the application of irrigation water at suitable times is maintained. The clay soils generally are more subject to crusting and other adverse conditions than are the looser soils. Fields in which the soil is of a heavy clay nature should have only slight slope, as water penetrates soil of this type slowly.

Beets on very sandy soils usually mature early and produce light yields unless irrigation water is abundantly supplied and a good state of fertility is maintained. Such soils should be irrigated in short rows, because the water penetrates rapidly. The unfavorable characteristics of sandy soil in relation to wind damage have already been mentioned. Beet plants start earlier in the spring on sandy soils and have a more vigorous growth during the first few weeks of the season. Unless care is taken, the beet crop on sandy soils may suffer from lack of moisture and from the effects of hot weather. The growing of beets on gravelly soils presents many of the difficulties discussed for sandy soils. It is frequently difficult to get a good stand of beets on gravelly types of soil.

The physical condition of the soil depends chiefly upon its type, previous handling, and previous cropping history. The physical condition has a close relation to the fertility of the soil, and this in turn depends largely upon previous handling. Fields may be improved by proper preparation of the seed bed, but the effects of crop rotation, drainage, and manuring are fundamental. Water-logged soils or soils lacking humus can not be easily improved by the normal operations of preparing the seed bed. Fertile soils with adequate water-holding capacity are easiest to keep in good physical condition. Soil for beets should be such that the fields can be quickly prepared for early spring planting. Fields that are difficult to prepare delay planting and require the expenditure of excessive amounts of labor. Soils of different types require varied means of preparation. Heavy soils are inclined to be too firm and light ones are inclined to be too loose for good seed beds, while medium loam soils are the easiest to place in proper physical condition for the planting of sugar-beet seed. Alfalfa or other sod lands are difficult to put into good physical condition and should be planted to some other crop for one year before being planted to beets, unless the returns are sufficient to pay for the extra labor of properly fitting such lands for beet growing.

The character of the subsoil must be considered in the selection of lands for sugar-beet growing. Its structure influences the height of the water table. It must be porous enough to allow ample drainage and at the same time not be so porous as to allow too great a loss of water through underground drainage. Because the beet is a deep-rooted plant it is imperative that the subsoil furnish its share of the moisture and plant-food elements. A subsoil that has a hardpan covered by 18 inches or less of good surface soil is not suitable for beets, and the same is true of fields with a shallow layer of soil over a loose, gravelly subsoil. The ideal beet field is one having a good depth of a fertile soil underlain by a subsoil of medium structure. Such soils permit slow and ample drainage of excess water, sufficient root penetration, and ample depth of feeding area for the plants.

IRRIGATION

The selection of irrigated lands for sugar-beet growing is not fully considered until a thorough examination of the irrigation water supply has been made. Land and irrigation water are sold as one item in most areas; and the value of the land for beets is largely dependent upon the water supply, for sugar beets must have an ample supply of water during the latter part of the crop season. The first irrigations depend largely upon the normal flow of the streams of the area, while the later irrigations are accomplished by the use of stored waters. As a whole, the streams of this area have a heavy flow of water early in the year when the snows of the higher altitudes are melting. These snows are mostly melted before midsummer, and the flow of the streams then diminishes rapidly. Alfalfa and grain crops can be irrigated easily by such waters, but the beet crop needs water later in the season. Only a limited acreage of beets could be grown in the irrigated areas without storage of the flood waters. Moisture can be stored in the soil in addition to that which is stored in the reservoirs. If the soil is not too wet it is well to practice irrigation in times of abundance of water, in order that the crop may

not need to call on the reservoir supplies so soon after the stream flows diminish.

Beets grow best when supplied with ample moisture. Excessive or deficient irrigation seriously injures the crop. Moderate irrigations applied at frequent intervals seem best for sugar-beet growing. The total quantity of water applied or the quantity used at any one irrigation varies for different climates and soils. Light sandy soils require more water than heavy soils. A shallow sandy soil is able to absorb and hold only 2 or 3 inches of water, while a clay loam can absorb and hold 5 or 6 inches or more of water at one irrigation. On sandy soils it may be necessary to irrigate every week during the summer months, while on other types there is no necessity for such frequent irrigations. Where irrigation water is limited, it is best to apply the bulk of the water during the middle of the growing season, rather than early or late, provided irrigation is unnecessary in order to germinate the seed. At one time there were popular opinions to the effect that irrigating the sugar beets early in the season prevented deep rooting, and that late irrigation reduced the sugar content of the beets. It has been found that these opinions are not based upon facts. The beets should be irrigated whenever the leaves turn a dark-green color or begin to wilt in midday and do not quickly recover at night. This is true whether the beets have only a few leaves or are nearing maturity. Early irrigations should not be as heavy as those later in the year. Many growers irrigate only in alternate rows when the beets are small. This is sufficient, especially on lands that subirrigate rapidly.

The following general comments on irrigation practice throughout the growing season will outline the usual methods followed in growing the sugar-beet crop. In some localities it is necessary to irrigate before or immediately after planting. In irrigating before planting, furrows are run 20 to 40 inches apart, depending upon the type of land (fig. 2), and the field is then irrigated. As soon as the land can be worked it is smoothed down and the seed planted. Where irrigation follows planting, it is advisable to attach ditchers to the drill to furrow the rows. Occasionally the soil type is such as to require that each row be furrowed, but usually irrigation applied in the alternate rows is sufficient. The furrows should be deep enough and smooth enough to insure a free flow of water between the rows without flooding, and the application should be continued long enough to bring about thorough moistening of the seed. It is not advisable to give a heavy irrigation at this time if the seed can be thoroughly moistened by a moderate application. As soon as the land dries it should be harrowed or cultivated. After the plants emerge and throughout the summer the beet crop should be irrigated before it suffers from the lack of water. Approximately 60 per cent of the space between the soil particles should be occupied by water for best results. Hot days and high winds increase and seasonal rains reduce the need for irrigation. Very fertile soils require somewhat less water per pound of crop produced as compared with soils of low fertility. It should be kept in mind that the beet plant can not absorb food from the soil except when these basic food materials are in solution. The beet feeds through the delicate root hairs which clothe the fibrous roots, and since many of these feeding roots

are in the upper areas of the soil, it is imperative that sufficient moisture be present in the feeding area to prevent reduction of food consumption by the plant through lack of water.

Care should be taken to distribute the water evenly in all furrows and to give all parts of the field an equal irrigation. If the distance between laterals is very long, the application of irrigation water may be uneven and water wasted. Washing and flooding are often caused by running too great a volume of water in a furrow. Flooding should be avoided in all cases, as it wastes water, forms crusts, and sometimes scalds the beets. The furrows and waste ditches at the lower end of the field should be watched closely to see that they do not become clogged and cause flooding. The beets should be irrigated late in the season, if necessary, to keep them in a growing condition. At digging time the soil should be in a good friable tilth, since where the soil is very dry there is a loss of roots by breaking, and on the other hand, if the soil is wet, mud clings to

FIGURE 2.—Ditching a sugar-beet field in preparation for irrigation of the seed bed before planting. Deep, straight furrows are essential to good irrigation

the beets, thereby increasing the tare. Therefore, the last irrigation should be timed so as to bring the land into good condition for harvesting. If during the harvest season the field becomes too dry, it is sometimes advisable to irrigate very lightly. Such a practice does not ordinarily reduce the quality of the beets.

DRAINAGE

Irrigated areas usually lack artificial drainage systems to dispose properly of the excess waters from irrigation and canal seepage. Lands that do not have good drainage are subject to increasing alkalinity. Some lands that once grew good crops have become so alkaline that they have been abandoned for beet growing. Such lands can be slowly reclaimed by the building of a proper drainage system and washing the land by abundant applications of irrigation water. It is better to install the drainage system before the land has

deteriorated. Adequate drainage can be provided by the use of tile or of open ditches. The initial expense is greater for tile drainage, but the maintenance is less if the system is properly installed. Open ditches are more wasteful of land, present a weed problem, and often cause irregular-shaped fields, all of which collectively tend to increase the cost of crop production. No rule can be given for any special type of drainage, as there are many local factors which must be considered. Tile drains should be placed in the ground below the deepest plow furrow, and at the same time should be placed near enough the surface to be quickly reached by the surplus waters. The drainage system must be installed so as to lower the water table from 3 to 4 feet below the surface of the soil and to carry off surplus surface and subsoil water to approximately the same depths. Local conditions and types of soil must be fully considered in the installation of a drainage system, as in some areas a much deeper tiling system is necessary than in others. There are areas and soil types where an open-drain system is the only feasible method of drainage. In some areas where the water table is high it is a common practice to make use of this for the subirrigation of beet crops. This method has been occasionally successful in some places, while in other areas it has caused the deterioration of large acreages due to the quick increase in alkali salts at the surface. A great many of the subirrigated areas should have drainage systems installed.

Excessive moisture content in the soil is not favorable to sugar beets. The young plants on such soils are most frequently damaged by root rots commonly called "blackroot." These or similar rot diseases continue to attack the crop throughout the season. High water tables also cause the beets to grow branched roots instead of the normal straight taproots. During dry seasons some of these wet lands are improved by the lack of rainfall and produce excellent beet crops. During wet seasons, however, the crops on such lands are the first to suffer from excess water. Wet lands are usually difficult to prepare early in the spring, and sometimes are too wet for proper harvesting in the fall. Such lands would be greatly improved by adequate drainage which would tend to equalize the water content of the soil. Not all soils that are naturally drained are good for beet growing under irrigation. This is especially true of those soils that are of loose sandy or gravel composition underlain by a subsoil of similar type. Such soils do not retain sufficient moisture for good crop growth.

CROP SEQUENCE

Any crop has a characteristic effect upon the soil in the nature of soil depletion, and in addition when it is continuously grown on the same field, injury from disease and insect pests as well as from weeds is intensified. The continuous growing of sugar beets often produces such unfavorable conditions for beets as to make the practice extremely undesirable. Since the growing of sugar beets leaves the soil in excellent condition for growing other farm crops, and since in like manner many other crops produce soil conditions very favorable for subsequent beet growing, a proper crop rotation is very desirable.

It is true that there are some successful plantings of sugar beets where the land has been used continuously several years for beets.

Such plantings are successful, however, only where the fields have had heavy applications of manure and the land has not become infested with the sugar-beet nematode. The application of all of the manure on one field benefits only one field at the expense of the other parts of the farm. Continued cropping to sugar beets almost invariably results in the land becoming infested with the sugar-beet nematode and the garden nematode, and eventually the single-cropping system leads to serious losses to the grower.

The type of rotation to use in connection with sugar-beet growing varies for different farms and different sections. The value of the other crops has much to do with their use in the rotation. Short rotations, such as grain and sugar beets or grain and alfalfa, are not usually so successful as longer rotations. In the case of fields infested with the sugar-beet nematode, beets should not be grown at less than 4-year or 5-year intervals. The long rotation which is desirable can be obtained by using some leguminous crop such as alfalfa, which, if not maintained too long, assists in keeping up the nitrogen content of the soil. Crop rotation should be so arranged as to give good seasonal distribution of labor. A rotation system which provides green crops to be plowed under is beneficial.

Several systems of rotation practice are successfully used. The crop sequence to be adopted depends on the type of farming practiced and whether or not the soil is infested with the sugar-beet nematode or other parasites. Where such infestation is prevalent, it is necessary to increase the period between the beet crops correspondingly. An example is seen in the 10-year rotation.

The rotation may be lengthened by the repetition of the cultivated 1-year crops before, after, or between the beet crops, or by continuing the alfalfa for a longer time if nematode infestation is serious. Some green growth should be plowed under at the close of the hay-producing period, and, where practicable, green-manure crops should be added to the rotation. In general, the following rotations are applicable to the irrigated areas under consideration:

5-year rotation

	Years
Grain and red clover	1
Red clover for seed	1
Miscellaneous (such crops as onions, potatoes, grain, melons, peas, corn, etc.)	2
Beets	1

8-year rotation

Grain and alfalfa	1
Alfalfa	3
Potatoes	1
Beets	1
Beans	1
Beets	1

10-year rotation

	Years
Grain and alfalfa	1
Alfalfa	3
Potatoes	1
Beets	1
Miscellaneous (such crops as beans, grain, etc.)	3
Beets	1

MANURES AND FERTILIZERS

All plants take certain elements from the soil and use them in the various structures of the plant, and when the crop is removed the soil is depleted to some degree. The amounts of these elements

removed depends upon the crop grown and the yield. Sugar beets remove certain plant foods from the soil, and in order to maintain maximum production these elements must be replaced in some manner. This replenishment is accomplished by the use of barnyard manures, commercial fertilizers, green-manure crops, and by the return of crop residues to the soil. These methods of maintenance of soil fertility need to be considered for the intermountain region. The use of barnyard manure in connection with the sugar-beet crop is a common practice. The plowing under of green crops is second in importance. The use of commercial or mineral fertilizers, although a standard practice in other beet-growing territories, is not yet fully developed in the intermountain region. It is improbable that beet growing can be continued there in a successful manner without an increasing use of all these methods of maintaining and improving soil fertility. The future cropping practices of the intermountain region will undoubtedly make use of all three types of treatment for this purpose.

MANURES

The use of barnyard manure in connection with the sugar-beet crop is a common practice. In many places such manure is not available in sufficient quantities to supply the need for humus or vegetable matter in the soil, and green manure must be plowed under as a supplement. Manure has another value other than the building up of the organic content and the returning of minerals to the soil, in that it affects the bacterial content of the soil, producing a so-called quickening action. Many of the soils of the Utah-Idaho area are high in plant foods, but these often occur in a form not readily available to the plant. The effect of green manure and barnyard manure is to make plant food available from the soil reserves. The use of crop residues can be attained most efficiently either by pasturing stock in the beet fields, as discussed later, or by utilizing manures from stock fed in a feed lot.

GREEN MANURES

The most valuable green-manure crops for use in this area are sweetclover and alfalfa. All rotations should include at least one green crop to be plowed under. The above types of green-manure crops build up the organic and nitrogen content of the soil. There seems to be little need for the purchase of mineral fertilizers excessively high in nitrogen where legume crops are plowed under and manure from stock fed on legume hay is used. Examples of the benefits obtained by the use of green-manure crops are common in all of the irrigated sugar-beet region, and those of northern Colorado and western Nebraska are noteworthy. During the last few years these two areas have surpassed all others in the increased use of green-manure crops with a coincident improvement of sugar-beet yields.

COMMERCIAL FERTILIZERS

Experimental work with commercial fertilizers in the intermountain irrigated area has not reached the stage where a definite statement can be made as to the best practices to be adopted. In some cases, because of the high state of fertility of the soil, sufficient

increase in crop yield resulting from the application of commercial fertilizers has not been obtained to warrant recommending them. In other instances the failure to secure profitable returns has been due to improper methods of application of the fertilizers.

In experimental trials the best returns from mineral fertilizers have been obtained by applying fertilizer of high phosphate content in the row below the seed at planting time and lightly irrigating the land immediately. This method distributes the fertilizer in the soil, makes it available for the young plants, and prevents possible injury from the fertilizer. This is important, since in many instances where fertilizer has been applied and irrigation omitted the fertilizer remained dry and did not become quickly available to the plant.

In other beet-growing areas high-percentage superphosphate has given good returns. This fertilizer is generally applied broadcast in a grain drill with fertilizer attachment prior to planting the beet seed.

Since these methods have been found to be of value in other sections, it is very likely that they will eventually be found beneficial in the Utah-Idaho area.

PREPARATION OF THE SEED BED

A properly prepared seed bed for sugar beets is deep, moist, and firm. The soil should be worked to a fine texture, and it should be smooth and level. Beet seed is properly planted when placed in moist soil about 1 inch beneath the surface in a seed bed that is deep enough to supply ample feeding area for the beet, which is a deep-feeding plant. Moisture is required to germinate the seed and to supply the young plants. Commercial fertilizers if used in the row with the seed furnish readily available food materials to promote rapid growth of the seedlings. A firm seed bed makes planting to an even depth possible, avoids future settling of the soil, assures even distribution of moisture, and affords a good contact between the seed and the soil. A seed bed of fine texture does not obstruct the roots in their natural growth. The seed bed should be level so that the depth of the planting will be even and the land can be properly irrigated. With beet seed planted in a good seed bed, a perfect stand and a good crop is obtainable, but with a seed bed lacking in any one of the requirements enumerated above there is much danger of a poor stand and a correspondingly lower yield. Many of the difficulties of seed-bed preparation are avoided by timely and proper performance of all operations.

A number of common farm implements are used in seed-bed preparation. There is some variation in their use, but in general it is necessary to use the turning plow, the disk, the spike-tooth harrow, and the leveler. The roller and the spring-tooth harrow are occasionally useful. They are especially useful when dry-soil conditions prevail which make compacting of the soil surface necessary or when it is advisable to pulverize a cloddy soil surface to a proper fineness.

PLOWING

Plowing is done to bring about a thorough turning, stirring, pulverizing, and mixing of the surface soil to a desired depth. The more thoroughly this is accomplished during plowing, the less labor

there is to be done with the other implements. The furrow slice should be cut to an even depth and to the width of the cutting edge of the plow. It is best to plow when the soil contains such an amount of moisture that the furrow slice will break and crumble when turned. Plowing when the soil is dry leaves clods, while wet plowing packs instead of stirring the furrow slice. In some areas the winter supply of moisture is insufficient to moisten the large clods, and it is difficult to prepare a satisfactory seed bed. (Fig. 3.) Such dry lands should be irrigated before plowing and, where possible, disked before plowing, to avoid crust formation. Careful harrowing or disking as soon as the land is plowed will save much work later. The modern 2-way plow is best for land that is to be irrigated, as it does not leave any dead furrows in the field. Subsoiling is not commonly practiced in the Utah-Idaho area. On some types of soils it might be profitable, but as a whole it has not as yet been considered essential.

Fall plowing has many advantages over spring plowing. Fall-

FIGURE 3.—A field plowed when very dry. The dry, hard clods remained in the field over winter. Unless sufficient moisture is applied to soften the clods, a great amount of labor will be needed to make a proper seed bed

plowed land retains winter moisture well. With the land thus prepared, early preparation of the seed bed and timely planting are possible. As a rule, fall-plowed lands produce the better yields. Since spring plowing must be hastily done, the land does not have time to pack properly before the seed is planted. Spring-plowed lands have many dry spots because they lose moisture while being turned. Although disking the land and planting the best seed without plowing permits early planting and saves moisture, this practice should be used only in extreme emergencies. Usually a much better crop is produced by fall plowing and an orderly system of seed-bed preparation.

Beet land should be plowed to a depth of 10 or 12 inches wherever previous practice and the soil type permit. Plowing to this depth forms a deep seed bed, destroys certain insects, and turns under some weed seeds to a depth that prevents their germination. Land not previously plowed deeply should be plowed not more than 1 inch

deeper each year until it eventually is turned to a depth of 10 to 12 inches.

CROWNING AND REPLOWING

In the irrigated areas alfalfa and sweetclover are common crops, and much of the land devoted to these crops is later planted to sugar beets. Alfalfa and sweetclover are excellent crops to grow in a rotation with beets, as they are a very valuable source of nitrogen supply. The roots of these plants, however, are often damaging to the subsequent beet crop. In a rotation using these crops, when the land is properly prepared for the planting of sugar beets the yields are very satisfactory, but where the land is poorly prepared failures are frequent. Since following alfalfa or sweetclover with beets presents these problems in soil preparation, the use of some other crop such as potatoes, beans, grain, or peas is advised. Several methods have been used to prepare alfalfa and sweetclover sod lands for sugar beets. Plowing when the plants are in the dormant stage leaves intact many of the roots, which send forth shoots that become troublesome as weeds the following season. If only a single plowing is given while the plants are dormant, it is best to grow grain on the land one year and to plant the field to sugar beets the following year. Double plowing cuts the alfalfa roots in short lengths. The first operation consists of a crowning or shallow plowing.

The crowns are allowed to dry for a period of two to six weeks and are then replowed to a depth of 8 to 12 inches. This process turns the heavy crowns deeply into the ground, where they do not interfere with cultivation; it also kills most of the plants. A better method is to plow while the crop is in a growing condition. Plowing in late August or early September is best, as the ground is warm and the turned-under green manure rots quickly. In this manner all of the roots and plants are destroyed, and their decay adds to the plant-food supply for the following crop. Sweetclover should be plowed somewhat earlier than alfalfa, so as to make certain that none of the plants are in a dormant stage. If the plants are left until spring to be plowed, they should be allowed to grow until the sprouts are about 12 inches high. It should be remembered that this delay in the spring often interferes with a safe planting schedule for sugar beets. However, where such crops are plowed under and the land is promptly irrigated, so as to rot the alfalfa or sweetclover quickly, this has been found to be a better practice than plowing these crops while in the dormant stage.

In some sections it is a common practice to plant crops such as potatoes or beans, rather than sugar beets, on spring-plowed alfalfa or sweetclover sods. The fact that these plants have a later planting date allows for more green growth and also more time for the preparation of the seed bed. This is a good practice, and under proper crop-rotation systems it provides fields in good condition for use for the sugar-beet crop.

HARROWING

The spike-tooth harrow is one of the most useful implements in the preparation of the seed bed. It may be used to break clods, to form a soil mulch, to destroy small weeds, to assist in leveling

the land, to prevent crusts, and to conserve moisture. Harrows are made in various sizes and shapes and with different sizes of spike teeth that can be adjusted at different angles. It is good practice to harrow all lands as soon as plowed, while the furrow slice is still in a friable condition and before dry clods have formed. One harrowing at this time accomplishes more than several later ones. In case of delayed planting, the field should be harrowed as often as necessary to keep the surface free from crusts and to kill weeds. Whenever beet land is leveled or smoothly rolled it should be harrowed immediately to form a light mulch on the soil. This prevents crusting and loss of moisture and reduces the possibility of blowing or shifting of the fine soil surface. All beet lands should be harrowed just previous to planting.

DISKING, ROLLING, AND LEVELING

Disking before plowing is an essential operation and should be practiced whenever possible. The disk is also a useful implement for stirring the soil to shallow depths and incorporating manure with the soil. It is especially useful in breaking up clods. In the case of fields that are foul with weeds, certain modifications of normal practices are sometimes desirable. Although in most cases it pays to plant the field of beets very early, in the case of foul fields it is suggested that planting be delayed until the surface weed seeds have sprouted. The field should then be disked or cultivated to destroy the first crop of weeds. This practice must be looked upon as a control measure to reduce the number of weeds and as a general measure for field improvement. Land infested with wild oats furnishes the best example where the delayed-planting method should be employed. Such land should be given a shallow plowing in the fall so that the oats will sprout early in the spring. The land should then be plowed deeply and disked or harrowed with the spike-tooth harrow. At best the growing of sugar beets on land infested with wild oats is not likely to give a large crop, for this pernicious weed usually crowds out some of the young beets and reduces the stand.

Three types of rollers are used in preparation of sugar-beet seed beds in the irrigated areas—the smooth roller, the corrugated roller, and the subsurface packer. Where land is spring plowed it is sometimes necessary to roll the land to obtain a sufficiently firm seed bed and to improve its texture.

The box leveler in common use in the irrigated areas is a very efficient tool. (Fig. 4.) It fills up small depressions in the land, crushes clods, and packs the soil. A seed bed seldom needs to be rolled or subsurface packed if it has been spike-tooth harrowed and leveled. These box levelers should be 16 to 20 feet long, as shorter ones do not fill in depressions. The plank drag performs some of the work done by a leveler, but is less efficient. Land should be leveled twice after plowing, and the second operation should be done at right angles to the first. If a third leveling is necessary, it should be made in the direction of the planting. As the leveler is a heavy implement and has a packing effect upon the soil, it should not be used when the land is wet or before large clods are broken

by the use of the harrow. Leveling is one of the last operations of preparing the seed bed. After the land is leveled one light harrowing fits the land for the reception of the beet seed.

EQUIPMENT FOR PLANTING

Beet-seed drills are of various types, and each has its advantages and disadvantages. The efficiency varies under different conditions, and there is a considerable divergence of opinion as to what type of drill is the best. Any of the standard types do good work if adjusted properly and operated in an efficient manner.

There are two types of feeding arrangements on beet-seed drills—plate feed and force feed. The plate-feed drills are inclined to leave the larger seeds in the drill, which should be cleaned occa-

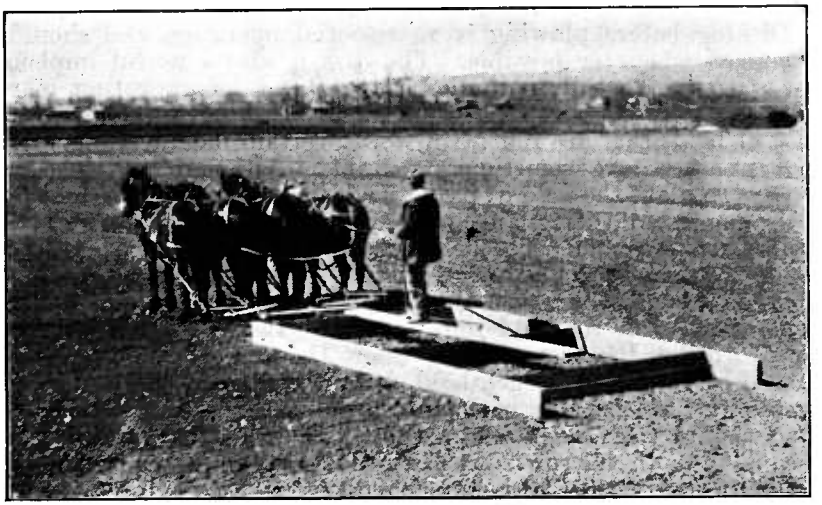

FIGURE 4.—The box leveler making a well-prepared seed bed. This illustration shows a number of items of importance in the preparation of a sugar-beet seed bed. The land has previously been leveled at right angles to the present leveling. The seed bed is so firm that the hoofs of the horses make only shallow, easily covered depressions

sionally, and the larger seeds planted with a plate having large holes. The force-feed drills need more care in adjustment to make certain that each spout distributes the same quantity of seed.

The covering arrangements are mostly limited to two types—the disk coverer and the shoe drills. The latter are more variable in type. The shoe drills depend upon the press wheels of two types, rigid and free, to cover the seed. It is usually possible to tighten the free press wheel so that it is rigid. With the rigid type the depth of planting is adjusted by the setting of the press wheels and the height of the tongue. When teams are changed or the tongue is raised by adjustment of the harness, it is necessary to recheck the depth of the planting. Since dull shoes do not plant so deeply as new ones, the adjustment of a drill is an individual operation for all used drills. Because of dragging the seed, some types of drill shoes plant seed at uneven depths. The actual per-

formance of the drill in the field should be watched carefully and adjustments made to fit the particular conditions.

Different sizes of seed are planted at different rates by drills. The ordinary method of checking a drill which is approximately correct is to plant a known acreage from a weighed quantity of seed and to weigh the remainder. The tongue of the beet drill should be stabilized to obviate play. Two straps or chains may be used to stabilize it. (Fig. 5.) This prevents the tongue from swaying and turns the drill back to proper position more rapidly than by depending entirely upon the harness. The rings in the ends of the neck yoke are fastened to the small rings on the inside hames of the opposite harness. The beet-seed drill should be care-

FIGURE 5.—A sugar-beet seed drill, showing attachment of chains from end of neck yoke to harness. This stabilizing device on the tongue is an aid in securing straight rows

fully adjusted and the following directions followed to secure its best performance:

Check the amount of seed planted by each drill spout separately.

Check the depth of soil penetration for each drill shoe separately, making necessary adjustments.

Set each drill shoe so that the depth remains permanently the same.

Tighten the neck yoke and straps so that the tongue does not sway up and down or sideways.

Check the setting of the marker device from both sides of the drill so that the proper guess-row width is obtained.

Clean the seed hoppers of a plate drill occasionally to remove large seed and any accumulation of seed trash likely to clog the plates.

Avoid planting wet ground with a shoe drill, as it will glaze and pack the seed row.

Determine that the press wheels firmly cover the seed in moist soil.

When the drilling of the main part of the field is completed, it is a good plan to cross plant the ends of the field used for turning, to keep down the weeds and to add to the productive area of the field.

FACTORS INFLUENCING STAND

DATE OF PLANTING

The important factors to consider in planting sugar-beet seed are date of planting, depth, quantity of seed, and proper mechanical placing of the seed in the soil. All of these factors are subject to some variation for differences in soils and climatic conditions. Beet seed is planted as soon in the spring as the soil conditions become favorable for its germination and growth. If other conditions are favorable, the beet seed will germinate well when the soil temperature is around 60° F. The young plants can withstand temperatures of 27° when the cold period is of short duration and the soil surface is moist, but it is advisable to delay planting until there is no danger of long-continued periods of cold weather. If the ground is wet and cold for a long period it retards the germination of the seed and the growth of the plants. In the irrigated areas such periods of weather are not of common occurrence, and early planting has, as a rule, given better results than late planting. The better yields resulting from early planting are partially due to the fact that early planting gives the beets a longer growing season. In curly-top years the advantage resulting from early planting may mean the difference between success and failure. Another factor in favor of early planting is the greater abundance of moisture early in the season in this region, which is subject to strong, drying spring winds that rapidly lower the moisture content of the soil. In some localities it is a common practice to delay planting a portion of the beet area so as to distribute the labor of thinning. It is doubtful if it is ordinarily profitable to delay planting if the land is in proper condition to receive the beet seed. Late planting is often more detrimental to yields than a corresponding delay in carrying on the thinning operations.

Beets that are planted very early are occasionally so seriously damaged by freezing or by other climatic conditions that it is necessary to replant the fields. It is often difficult to determine whether to replant or to continue with a partial stand. It must be remembered that beets frequently show unexpected powers of recovery, and there is no assurance that the replanted crop will have conditions favorable for a perfect stand. Where replanting is done, the beets have the disadvantage of a late start. In case it seems advisable to replant, it is generally necessary to irrigate immediately after seeding, in order to avoid any further delays. The variations in yields from date-of-planting tests illustrate the situations commonly met. For example, in 1926 a delay of 13 days in time of planting caused a reduction of 4.78 tons of beets per acre. In 1927 a delay in planting from March 30 to April 13 reduced the yield 0.47 ton per acre, and a further delay until April 26 gave a further reduction in yield to the amount of 1.1 tons per acre. In this season late planting was less detrimental than in 1926. The late planting usually produced beets with a lower sugar content than that of the early planted beets. It is evident that no exact date of planting can be given, since seasons vary so greatly; but experience in the intermountain region has shown that beets should be planted as soon as weather conditions permit.

DEPTH OF PLANTING

It is normally advisable to plant sugar-beet seed from 1 to 1½ inches deep, and in only very special cases should the seed be planted less than 1 inch or more than 1½ inches deep. Planting at one-half inch depth gives good results where the land is very moist and when there is no danger of drying winds. Planting more than 1½ inches deep is considered necessary in some fields where there is a

FIGURE 6.—Sugar-beet seed planted at 3, 2, and 1 inch depths in a good seed bed. Note the straight growth of seedlings in contrast with the type of growth obtained with a poorly prepared seed bed (fig. 7)

lack of moisture, but deep planting frequently results in poor germination and weak plants. The general effects of planting at different depths and in a good and a poor seed bed (1, 2, and 3 inches) are illustrated in Figures 6 and 7. The 1-inch depth of planting in a good seed bed is far superior. In Figure 7 the detrimental effect of poor soil preparation is well illustrated. These illustrations represent what is being enacted on a large scale in the field and graphically typify the difference between the right and the wrong way of beet-seed planting.

RATE OF PLANTING

Not only the depth of planting, but also the quantity of seed to be planted, influences the yield of sugar beets. The quantity of seed varies with the condition of the seed bed, the climate, and the quality of the seed. In general, sugar-beet seed is of standard quality, and

FIGURE 7.—Sugar-beet seed planted at 3, 2, and 1 inch depths in a poor seed bed. The seeds planted 3 inches deep show the least vigor, and those planted 1 inch deep show the most vigorous plants. Note the lack of straight growth of stems and roots. These plants are 30 hours older than the plants shown in Figure 6

the quantity commonly planted per acre (15 to 20 pounds) is sufficient to furnish a satisfactory stand. Although a slightly smaller quantity of good seed planted under ideal conditions will produce a good stand, the few extra pounds of seed required for the heavier rate of seeding is considered cheap insurance against the danger of a poor stand. An extra quantity of seed will not make up for careless planting or poor preparation of the seed bed. There is sufficient

difficulty in obtaining a good stand of beets when one contends only with unavoidable damage. It sometimes occurs that planting 15 to 20 pounds of seed per acre produces a great abundance of plants. These extra plants have to be removed at thinning time. It is probable that such stands should be thinned earlier, before crowding does injury, than the less dense stands which are less affected by crowding. The ideal stand for easy thinning is one where there are relatively few beets so evenly distributed in a row as to allow the desired spacing to be obtained. Single beets are not affected by crowding. They make a prompt and sturdy growth and are easiest to handle in the thinning process. However, a seeding rate that would give such a sparse distribution is likely to produce an uneven stand of beets. It is therefore desirable to use heavier rates of seeding to insure a stand of seedlings in spite of adverse conditions.

SOIL CRUST

Crusting of the soil is one of the very common causes of failure to obtain a good stand of sugar beets. Heavy rains pack the soil and lead to crust formation, especially where the drying is rapid. Some sandy soils do not crust, but all heavy soils are subject to this difficulty. The nature of the beet seedling is such that it is very important to maintain a loose mulch on the field during germination, as the small beet seed does not contain more than enough food reserve for the few days of normal growth necessary to bring the seed leaves above the ground, and the young slender stem which is tipped by the two small cotyledons is not very efficient in breaking through a hardened soil surface. Seedlings that are retarded in their penetration of the soil surface are weakened or killed. The plant stems are bent or curled, and in instances where the cotyledons are near the surface they receive some light which causes them to open prematurely. Such conditions lead to the death of the young plants, with the result of a greatly reduced stand. It is therefore necessary to adopt all possible measures to prevent crust formation or to break the crust after it does form. Many methods are used to prevent and break crusts on the beet fields. Prevention is much better than breaking the crust after it has been formed. Planting in a seed bed with a good mulch is the first essential of prevention. If a storm comes, the land should be harrowed with a light beet harrow as soon as it is dry enough for the use of this implement. Blind cultivation of the rows before the plants have reached the surface is also excellent. Harrowing with a heavy harrow often disturbs the seeds and is not advisable. Rolling breaks the crust, but if the land is wet the roller may pack the subsurface too tightly and damage the crop.

If the seed is planted at too great a depth to permit rapid germination a heavy harrowing is beneficial when done at right angles to the direction of the rows. This should be done before all of the seeds have germinated and when the land is in a friable or dry condition. If a very heavy crust forms on the land, the use of vigorous methods to destroy it is warranted. The corrugated roller is usually the best implement to use.

HANDLING THE GROWING CROP

Since a number of salient points are to be considered in each of the various operations involved, the following items in handling the sugar beet from the seedling stage to maturity are discussed in detail. Great emphasis is placed on the importance of obtaining first-class hand labor to perform in a proper manner the blocking or spacing of the beet plants, the selection and retention of the strongest and healthiest plant, and the thorough and careful hoeing of weeds from the beet row.

SPACING

The number of sugar beets to grow per acre varies somewhat for different areas and different fields. The present accepted standard is 26,136 beets per acre, which is the computed number of beets in a perfect stand spaced 12 inches apart with 20-inch rows. In the study of a large number of plots it was found that the maximum yield was produced, in the area under consideration, when the beets were spaced approximately 10.3 inches apart in 20-inch rows. Closer spacing to 8.8 inches reduced the yield to 4.3 per cent, or less than 1 ton. In these tests the 10.3-inch spacing produced an average yield of 18.79 tons of beets per acre, compared with yields of 17.99 tons for 8.8-inch spacing, 17.74 tons for 12.3-inch spacing, 15.61 tons for 15.3-inch spacing, 13.11 tons for 20.2-inch spacing, and 9.82 tons for 30-inch spacing. Under normal conditions the increases of yield from growing more than the 12-inch stand are not usually sufficient to more than pay for the increased cost of production, but the losses caused by 15-inch or 20-inch stands are such that they greatly reduce the profits gained from proper sugar-beet growing. The majority of the commercial fields are now producing beets in fields that have from 60 to 80 per cent of a perfect 12-inch stand in 20-inch rows, which are approximately 15-inch and 20-inch stands. It is believed that the majority of growers would be benefited by closer than present spacing.

As the curly-top disease is a factor in much of the area under consideration, the effect of spacing distance is considered with reference to yields in years when curly top is prevalent and in years when the disease does not appear. The number of beets per acre as determined by stand counts and the corresponding plot yields for 1925 and 1926 were compared. In 1925 the beets suffered practically no injury from the curly-top disease. The figures obtained for that year indicate that a spacing closer than 12 inches did not produce a marked increase in yield. In 1926, a year of severe injury from curly top, beets that were closely spaced (8 to 10 inches) produced the best results. Upon comparison of the results obtained in these years it was noted that in 1925 (no curly top), as the spacing between beets increased, the size of root increased, whereas in 1926, under curly-top conditions, the average size of beet remained practically fixed, irrespective of the spacing. In 1925 the range of size of average beets was from 2.85 pounds per beet where less than 10,000 beets were grown per acre to 1.58 pounds average weight of beets where 30,000 beets were grown per acre. In 1926 the average weight of beets for these respective stands was 1.03 and 1.06 pounds. Such data indicate the advisability of closer spacing in curly-top areas.

BLOCKING AND THINNING

Thinning should begin when the beets have 4 leaves and should be rushed along to completion by the time the beets have 8 to 10 leaves. Small beets are easiest to thin and suffer less from crowding than large ones. There is experimental evidence to indicate that early thinning produces better yields than later thinning. This recommendation can be made for those fields in which damping-off, or blackroot, is not a factor. The early thinned plants avoid the detrimental crowding conditions experienced by the plants thinned later. On the other hand, it is practically impossible to be certain that damping-off of seedlings will not develop in sugar-beet fields. The practice which is now coming into favor in the handling of sugar-beet seedlings in the intermountain region, especially in fields where blackroot is a factor, is to delay thinning until there is marked differentiation between the healthy and the diseased beets. Healthy beets in a row are sturdy and have straight petioles, whereas diseased seedlings are backward and have bowed petioles. Thinning should be delayed until the distinction between the sturdy and the weak seedlings is plain.

The thinning and blocking of beets is done in one operation by the use of short-handled hoes or in two operations if long-handled hoes are used. Either method is satisfactory if carefully done. Narrow, sharp hoes are necessary for good thinning. Wide hoes cause unduly wide spacing of the beets, and dull hoes do not cut deep enough to kill all weeds and all the beet plants that should be removed. As a rule, the use of the short hoe is quicker but is conducive to poorer work.

The purpose of blocking is to remove quickly and easily the surplus beets between the tufts of beets from which the best individual is to be selected, since only one beet should be left in a place. Where blocking and thinning are done as two separate operations, excellent results are obtainable because each operator has but a single task to perform.

The best results in handling the stand of seedlings will be obtained if the following method is closely followed: In this work one laborer blocks the beets and another thins to a single plant. This blocking requires two strokes of the hoe for each beet left. The first stroke is made to block out a tuft of beets 3 to 4 inches long, and the second stroke reduces the number of beets left in the tuft. Satisfactory work requires that the first stroke be made to mark out the tuft in the row, and the second is made merely to reduce the size of the tuft by a cut to the rear of the cut made by the first stroke. This method, which laborers quickly learn to perform, gives more even spacing and results in a better final stand than the common method where the first stroke marks out a tuft of beets and the second stroke merely widens the first spacing. Unless the former method is used and careful supervision of the operation given, careless laborers will block out two full widths of the hoe or more (12 to 15 inches) preliminary to thinning to a single beet. The small tuft of beets remaining after the blocking operation is thinned by hand to one beet. As has been explained, the largest and healthiest seedlings should be left. In actual tests, selection of the large, healthy seedlings has produced yields several tons per acre greater than were obtained by leaving the smallest beets. The practice of removing the seedlings most con-

veniently pulled instead of making careful selection to leave only the sturdy, healthy beets is entirely too common.

Since poor work may reduce the yield of beets by 3 to 5 tons per acre, the grower can well afford to supervise closely the workers who are blocking and thinning beets to see that superior work is done. Uniformity of size and stand make for a more complete utilization of all parts of the field, and therefore are desirable fac-

FIGURE 8.—A group of sugar beets in actual position as they grew in the row, showing the variation in size of the plants and the proper depth of cutting out surplus beets. Note bowed petioles of certain individuals; these are diseased

tors in the growing of sugar beets. Any practice which destroys the stand usually decreases the yield. It is therefore imperative for the grower to acquaint himself with the best thinning practice and to supervise his laborers so as to conform to the following instructions:

Leave the largest and healthiest plants, one in a place at intervals of 10 or 12 inches.[1] (Figs. 8 and 9.) With seedlings of fair size, the characteristic straight petioles serve to identify the healthy individuals.

[1] The closer interval would seem preferable in a curly-top year.

Make the first stroke to space the tuft and the second to reduce the number of beets in the tuft.

Hoe crosswise of the row, cutting just deep enough to kill all weeds and surplus beets.

Drag as little as possible of the dirt away from the row.

Leave the beets standing as erect as possible and the roots covered with loose dirt.

MECHANICAL BLOCKING OF BEETS

The question often arises whether it is possible to block beets mechanically. In good stands of sugar beets it is possible to use a

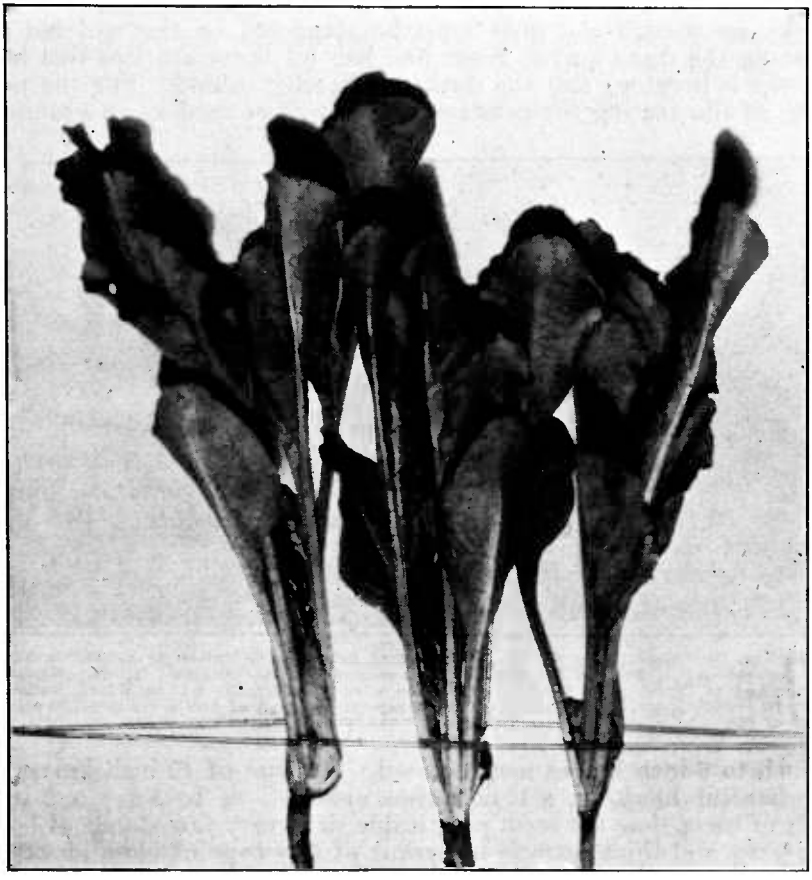

FIGURE 9.—The three largest beets of the group in Figure 8. Compare these with some of the smaller beets in the same group. The largest and healthiest seedling of a group should be left when thinning

beet cultivator to block the beets partially, but poor and uneven stands can not be so handled. Mechanical blocking saves a part of the labor usually necessary to block and thin the crop. It is especially advisable where thinning is to be delayed, as the early blocking with a cultivator diminishes the deleterious effect of crowding. Some single beets are properly spaced and thinned and have the advantage of early thinning. In weedy fields the cross-cultivation resulting from mechanical blocking is very beneficial.

Mechanical blocking can be done with the knives commonly used on the sugar-beet cultivator. A knife should be set to cut the space covered by each wheel of the cultivator. It is advisable to turn the blades of the end knives inward. When used without a shield of some sort, duckfeet are not so efficient as knives, as they cover more of the remaining beets. Some growers use the disk cutter as a suitable shield. This cutter makes a clean cut without disturbing the block of beets. Irrespective of type of tool used, the cultivator should be fitted with a marker to enable the operator to make even-width guess rows. In spacing the tools used on the cultivator bar they must be varied with the stand of beets. In case duckfeet and disks are used, these tools must be staggered on the tool bar by placing the disks on the front tool bar (if there are two tool bars on the cultivator) and the duckfeet directly behind. For the purpose of illustrating the practice, knives will be used as an example;

FIGURE 10.—Sugar beets mechanically blocked by cross-cultivation as a labor-saving operation: A, Part of the field which was mechanically blocked; B, the original stand of beets. The blocking was done with a cultivator having 6-inch knives 10 inches apart, thereby leaving an average final stand of 108 beets per 100 feet of row

6-inch to 8-inch knives may be used. The use of 10-inch knives in mechanical blocking, set 12 inches apart so as to leave a 2-inch tuft of beets, does not seem practicable since very few stands of beets are even and thick enough to permit of this type of close blocking. It is preferable to use 8-inch knives set 12 inches apart or 6-inch knives set 10 inches apart to leave 4-inch tufts of beets. The latter method was used in an experimental field in 1927, an average of 108 beets being left to 100 feet of row. (Fig. 10.) The method presents many possibilities with fields of good initial stand, and it should be tried in comparison with the ordinary methods.

HOEING

Careful work during thinning operations will greatly reduce the amount of hoeing necessary later on. Where due diligence is exercised during thinning by thorough hoeing, the space between and

around the beet plants will not only destroy all weed growth but will greatly assist in creating an effective soil mulch.

The first hoeing of beets is usually done in a week or 10 days after thinning, and a later hoeing is performed when large weeds appear in the fields. Ordinarily two hoeings are sufficient for the average field, but weedy fields often require more attention. In the case of the second hoeing when performed later in the season, it is a much better practice to pull the weeds by hand than to hoe them. Weeds should generally be pulled immediately following irrigation. The use of a hoe at this stage of crop development usually causes more harm than good, since the beet leaves cover the rows to such an extent that the laborer can not see where the hoe strikes. Such a blind operation may result in many of the beets being cut. It is a far better practice to pull all such later weed growth by hand where reasonably good work has been done in the earlier hoeing. The use of a hoe tends to fill the irrigation ditches, which often necessitates refurrowing the field for further irrigation.

CULTIVATION

Sugar beets require five or more cultivations during the season. At least one of these should be performed before thinning, another within a day or two after thinning, and others later at intervals until the leaves cover the rows. A close deep cultivation soon after the beets are thinned prevents a drying out of the roots and hastens growth. This can be done most easily in the early morning when the plants are standing erect. Cultivations can be made after the leaves cover the rows, if done in midday when beets are somewhat wilted. Too many leaves are broken if the beets are cultivated when the leaves are turgid. Small beets may be cultivated most easily early in the day when they are most erect.

Cultivation serves to kill weeds, conserves moisture, loosens and aerates the soil, and improves the condition of the soil. All these factors have the net result of benefiting the crop. Weeds are most easily killed when small, therefore early cultivation should be frequent and effective. When a mulch has been established, the weeds killed, and the ground loosened to a depth of approximately 3 inches, there is no further need of frequent tillage if the land remains in this excellent condition. Further tillage is necessary only as storms occur and form crusts, or as small weeds appear.

While close deep cultivations are essential in the early development of the beet plant, care must be exercised to so set the cultivator tools for later cultivations that the lateral roots are not injured.

Different tools are used for the various cultivations. (Fig. 11.) The first cultivation should be done with the knives or disks set close to the row and a duckfoot cultivator run deep in the middle of the rows. If the land is crusted or littered with trash, the disks operate more efficiently than the knives. On such land it is sometimes necessary to use the duckfoot in the center of the row as a separate operation from the use of the knives or disks, but on most lands the complete equipment can be used in one operation. The knife-edged bulltongues are used for the cultivations when a deep mulch is desired. Three of these are used between each pair of rows,

with the middle one set deeper than the others. This is a new type of equipment and is not so commonly used as duckfeet, knives, and deertongues. Large or small ditchers are used for making irrigating furrows, the choice of these depending upon the type of soil. The ditches are not difficult to make in fields that are properly cultivated. When irrigating before the leaves cover the ground, it is advisable to cultivate as soon as the land is dry and reditch for future irrigations.

Early cultivation conserves moisture, maintains the mulch, and kills the weeds when they are small and easily destroyed. These first cultivations are usually done with a cultivator equipped with knives or disks. Disks are good for cultivating close to the beets, but often leave the plants on a narrow ridge where they are in danger of injury from drying. It is a good plan to use duckfeet along with the disks or knives. (Figs. 12, 13, and 14.) If the duck-

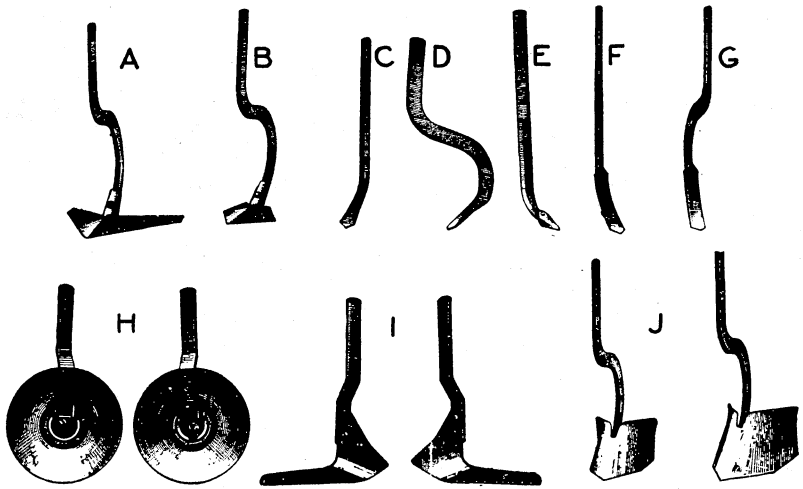

FIGURE 11.—Beet-cultivator tools; A, Large duckfoot; B, small duckfoot; C, straight-shank calftongue; D, curved-shank calftongue; E, knife-edged calftongue; F and G, diamond-point shovels or bulltongues; H, disks; I, knives; J, irrigating shovels, small and large

feet are set deep and the soil is in a loose, friable condition, they do not cover the beets. Close cultivation with knives covers more plants but does not throw the dirt away from the row as much as the disks. The proper adjustment of the cultivator tools is very important and must be varied to suit the individual fields. Four-row cultivators are adjustable so that the tools can be correctly spaced to fit four beet rows as planted by the drill. Tools when set on the heel or set flat do not penetrate as well as those set to run on the point. Duckfeet if nosed down too much throw dirt on the rows. The levers on the cultivator are easiest to operate when the tools are set to dig into the soil. Loose, swinging neck yokes or harness cause the cultivator to follow the beet row irregularly.

HARVESTING

The beginning of the sugar-beet harvest is determined by the purchasing company's announcement of readiness to receive the beets.

This date is governed by the ripeness of the crop as determined by field samplings. After permission to harvest is granted, the grower may begin immediately or may delay handling the beets until later

FIGURE 12.—Cultivation of sugar beets with disks only. The field is left uneven

in the season. There are advantages in both early and late harvesting. If the beets are in a growing condition the yield increases until such time as the conditions become unfavorable for growth. On the other hand, there is some danger of unfavorable weather conditions that stop the growth and make the harvest difficult.

FIGURE 13.—Cultivator equipped with disks and duckfeet. The field is left in better condition than the one shown in Figure 12

Freezing does not often destroy the beets, but snow and freezes make harvesting more expensive. Early harvesting permits more fall plowing and other work in preparation for the crop of the follow-

ing year. Beet-harvest time is one of the busiest seasons of the year, and it is more profitable to harvest in an orderly manner with the size of crew that completes harvesting the crop before there is loss from storms.

Beets are lifted by a double-pointed puller which lifts and loosens them from the soil. The proper adjustment of the beet puller is very important. A poorly adjusted puller leaves a portion of the beets in the ground or breaks off the roots. These losses sometimes amount to a ton or more of beets per acre. Old and worn puller points often cause a puller to tilt behind and break off the roots of many of the beets.

Careful topping is very essential. The beets should be topped in a manner that meets the requirements of the receiving company. It is usually specified in the grower's contract that the beets shall be topped at right angles to the long axis of the beet and at a point indicated by the lowest leaf scar. To top lower than this reduces the tonnage. To top higher than this is useless, as the receiving company samples and tares the beets and deducts from the weight an amount estimated to be the excess crowns left on the beets.

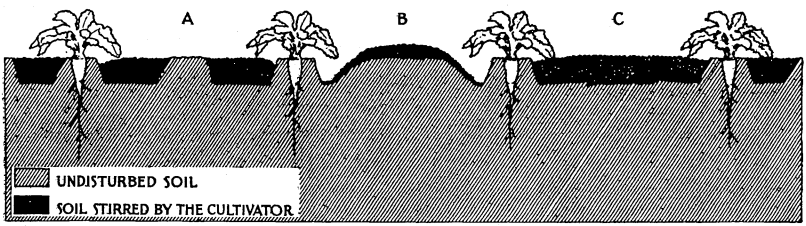

FIGURE 14.—Diagram illustrating results obtained with a cultivator equipped with various types of tools: A, Cultivation with knives; B, cultivation with disks; C, cultivation with knives and duckfeet—the best method of cultivation

In some areas the toppers pile the beets and top them from the piles. The piling reduces the dirt tare, as the double handling shakes more of the dirt from the roots. In other areas the toppers use a knife with a hook attached to the point and top the beets from the row at one operation. The hooks on the knives permit of more rapid topping, but are objected to in some areas since the wounds caused by the hooks are often the starting point for storage rots. A smooth spot should be prepared for piling the beets in the field. In this manner the beets are easier to load and less dirt is thrown into the wagon and hauled to and from the receiving station.

Dirt returned to the grower at the receiving station should not be dumped in the field because of the danger of introducing nematodes in this way. The machinery of the receiving station can not be cleaned sufficiently to prevent a slight carry-over of dirt from one load to another, and many cases of field infestation with nematodes are traceable to the dirt brought back to the field from the sugar-beet dump.

Beets should be hauled immediately after digging, unless they are sufficiently covered with tops or soil to prevent drying or freezing. The loss in weight of beets left in the field after being topped varies greatly with different weather conditions. In one instance beets left in the field for 72 hours after harvest lost less weight

than beets left in the field 17.5 hours. In the first instance there was a period of rainy and cloudy weather, while in the second the weather was very dry and windy. Another experiment indicated that there is some loss where beets are left in the field only a few hours. The loss from small piles is sometimes over 5 per cent of the weight of the crop in 24 hours, and the loss from three days of exposure in small piles amounted to over 20 per cent. Covering a large pile with tops saved nearly 10 per cent of the total weight when beets were left in the field for two days. Beets left in the field for a long period of time and covered with tops lost less weight than those exposed, but neither method of field storage was satisfactory. It is general experience that large piles lose less weight than small piles. Therefore, if immediate delivery of topped beets is impossible, the heavy shrinkage losses can be greatly reduced by making fewer large piles instead of numerous small ones. In any case, the piles of freshly topped beets should be covered with a liberal quantity of beet tops.

For many years there has been a continuous attempt to perfect several types of machines designed for harvesting and topping the beets by one mechanical operation. At present there are none in common use. Recent improvements in design of such machinery indicate that the outlook is encouraging for development of practicable mechanical means of beet harvesting.

SUGAR-BEET BY-PRODUCTS

BEET TOPS

In harvesting sugar beets the crown and the tops are removed from the root and discarded. These are usually dropped in the field until after the harvest is completed. In most beet-growing areas the tops are fed by simply pasturing stock in the fields. This method has been found to be satisfactory in the irrigated areas. The average feed value of 1 acre of beet tops is approximately the same as the feed value of 1 ton of alfalfa hay. Such an estimate of the value of an acre of beet tops is somewhat indefinite, but it gives a good method of estimation by the comparison with a common stock feed of the area. (Table 1.) From 3 to 8 tons of green tops are produced from an acre of beets.

TABLE 1.—*Percentage composition of by-products of sugar beets*[1]

By-product	Water	Solids	Ash (total)	Protein (N × 6.25)	Reducing substances (direct as invert sugar)	Apparent sucrose (reducing sugar method)	Nitrogen-free extract (including sugars)	Fat (crude ether extract)	Crude fiber	Total apparent sugars (sucrose plus invert)
Fresh tops	74.80	25.20	6.36	4.03	0.84	3.18	11.81	0.26	2.73	4.02
Top silage	66.82	33.18	13.96	3.73	.79	.24	11.28	.44	3.78	1.03
Wet green pulp	90.99	9.01	.38	.90	.02	.04	5.73	.05	1.95	.06
Dried pulp	7.48	92.52	4.41	9.76	.25	.52	56.95	.52	20.88	.77
Pulp silage	90.48	9.52	.61	1.38	(2)	(2)	3.95	.18	3.40	(2)

[1] Compiled from United States Department of Agriculture Circular 319, Composition of Sugar-Beet Pulp and Tops and of Silage Therefrom.
[2] Trace.

Some growers allow the tops to become wilted and then pile them in small piles for further curing, and either pasture the cured tops or haul them to the feed racks. This method involves more labor, but a greater feed value is obtained. Another method is to put the tops into a silo or pit where they are mixed with an equal amount of straw. This involves the expenditure of more labor than pasturing. Siloing has been found to be profitable where the silage was properly made and there was not too much dirt adhering to the tops. Some unfavorable results have been obtained by feeding beet-top silage that contained too much dirt. Moist and wet tops carry more dirt than dry ones. Methods have been proposed for washing dirt from tops to be siloed or fed in the feed racks, but such practice is not in common use.

Green beet tops are succulent, and stock should have additional concentrated feed in the ration. Beet tops when fed to dairy cows in large quantities may impart a disagreeable flavor to the milk. This may be overcome in part by feeding the tops following milking.

A small quantity of fresh beet tops does not injure horses or mules, but feeding moldy or spoiled tops or silage is unsafe. The tops should be more generally utilized for cattle and sheep feeding. The succulent ration of green or siloed beet tops is of special value in feeding, as it is available at a time of year when there is a scarcity of other succulent feeds. Beet tops are sometimes plowed under for their benefit to the soil. In most instances it is more profitable to pasture or feed them and return the manure to the soil.

BEET PULP

Beet pulp is a by-product that remains after the beet roots have been sliced and the sugar extracted. Most of the sugar manufacturers sell this by-product to the livestock feeders in the vicinity of the factory at a low cost. The pulp is an excellent stock feed and may be fed in the fresh, dried, siloed, or pressed form. The greater portion of the pulp in the irrigated area is conserved in silos, but many factories are now pressing and drying the pulp. Analyses of pulp are given in Table 1. Green pulp and siloed pulp are commonly fed to feeder stock, while dried pulp is often fed to dairy cows. Dried pulp has the advantage of being a more concentrated feed than cured or pressed pulp. It is more easily kept and stored for long periods and does not have an odor that is imparted to the milk. Pulp is most profitably fed when more concentrated feeds are added to the ration.

MOLASSES

Molasses from the beet-sugar mills makes a good stock feed when added to other feeds, such as pulp, beet tops, hay, or grain. It contains about 50 per cent of digestible carbohydrates and has a high feeding value when fed in a ration. The most common use of beet molasses is to feed it mixed with ground alfalfa hay or beet pulp. Beet molasses contains approximately 5 per cent of potash salts and can not be fed in large quantities to any stock. From 3 to 5 pounds per 1,000 pounds of live weight may be fed daily.

LIME

Waste lime has not been made use of by the beet-sugar factories of the irrigated areas except in a few isolated instances. At most factories it is sluiced into settling basins or streams and not used. The soils of the area are not lacking in lime, and very few growers have found that the addition of lime to the soil was of any marked benefit. Near some factories there have been found low areas, which were filled with the waste lime combined with waste water from beet washings and from the Steffins houses. This practice has reclaimed some valueless lands, and in several instances excellent beet fields have been built up. In the humid areas of the United States and in Europe more use has been found for the waste lime. Fresh waste lime contains approximately 0.3 per cent nitrogen, 0.5 per cent phosphoric acid, 0.2 per cent potash, 81 per cent calcium carbonate, and about 13 per cent organic matter, all of which have some value for some types of soil.

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